

**COMPREHENSIVE NEEDS ASSESSMENT FOR  
CHINOOK SALMON HABITAT IMPROVEMENT PROJECTS  
IN THE SAN JOAQUIN RIVER BASIN**

March 1994

Prepared for the California Department of Fish and Game  
by the  
California Department of Water Resources' San Joaquin District  
under Contract FG20841F/165038

## Memorandum

Date: March 25, 1994

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From: Department of Water Resources

Subject: Comprehensive Needs Assessment for Chinook Salmon Habitat  
Improvement Projects in the San Joaquin River Basin

This report presents the findings of a comprehensive needs assessment for chinook salmon habitat improvement projects in the San Joaquin River Basin. The report completes Contract FG20841F/165038 between the California Department of Water Resources and the California Department of Fish and Game.

Questions about the information in this report should be directed to Paula Landis of this office at (209) 445-5289.



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## TABLE OF CONTENTS

|                                       | <u>Page</u> |
|---------------------------------------|-------------|
| Introduction .....                    | 1           |
| Site Selection Criteria .....         | 3           |
| Restoration .....                     | 5           |
| Preliminary Cost Estimates .....      | 7           |
| Site Assessments and Selections ..... | 9           |
| Stanislaus River .....                | 9           |
| Tuolumne River .....                  | 9           |
| Merced River .....                    | 10          |
| Bibliography .....                    | 23          |

### Appendices

|   |  |    |
|---|--|----|
| A | Stanislaus River Preliminary Designs ..... | 25 |
| B | Tuolumne River Preliminary Designs .....   | 39 |
| C | Merced River Preliminary Designs .....     | 49 |
| D | Stanislaus River Priority Sites .....      | 59 |
| E | Tuolumne River Priority Sites .....        | 69 |
| F | Merced River Priority Sites .....          | 81 |

### Figures

|   |  |    |
|---|--|----|
| 1 | Stanislaus River Salmon Habitat Assessment ..... | 11 |
| 2 | Tuolumne River Salmon Habitat Assessment .....   | 15 |
| 3 | Merced River Salmon Habitat Assessment .....     | 19 |

### Tables

|   |  |    |
|---|--|----|
| 1 | Stanislaus River Potential Salmon Habitat Improvement Projects ..... | 13 |
| 2 | Tuolumne River Potential Salmon Habitat Improvement Projects .....   | 17 |
| 3 | Merced River Potential Salmon Habitat Improvement Projects .....     | 21 |

## INTRODUCTION

The Department of Water Resources, with biological and fisheries assistance from the Department of Fish and Game, conducted a comprehensive assessment of salmon habitat in the San Joaquin River Basin. The assessment identified types and locations of projects that can be constructed to improve salmon habitat on the Stanislaus, Tuolumne, and Merced Rivers. The assessment will be used to develop priorities for a systematic approach to habitat restoration in the San Joaquin Basin. The purpose of this investigation was to develop a list of potential habitat restoration projects and their relative priorities for construction. This approach will make the best use of available funds and will provide immediate benefits to San Joaquin salmon populations. Past restoration projects were identified and constructed on an individual basis. Benefits were determined on a site-specific basis rather than in the context of the overall river system. A total of 46 sites were identified; 23 of those sites were determined to be high-priority sites. In addition to the overall assessment, preliminary engineering was provided for ten spawning riffles at seven sites. The preliminary engineering was provided to expedite project implementation. Four types of restoration projects were looked at: (1) restoration of salmon spawning riffles, (2) isolation of predator habitat, (3) improvement of the migratory path, and (4) enhancement of rearing habitat. The 46 sites identified as feasible fall into the first three categories.

## SITE SELECTION CRITERIA

Biologists from the Department of Fish and Game and engineers from the Department of Water Resources surveyed salmon spawning reaches of the Stanislaus, Tuolumne, and Merced Rivers. The criteria used to assess potential sites include historic use by salmon, bed slope, channel width, water depth, water velocity, bank vegetation, substrate conditions, potential for habitat diversity, adjacent land use, construction access, and potential quantifiable benefits. The potential for habitat diversity was also considered in selecting sites. Sites less than 100 feet in length are not addressed in detail in this report.

Sites were prioritized based on (1) their biological value and (2) the combined engineering feasibility and cost of project construction. Biological values were determined by the Department of Fish and Game, and engineering feasibility and cost were determined by the Department of Water Resources. In each of these two categories, a site was rated from one to three, with one being the highest. The ratings for each category were then added together. A total rating of two indicated a high-priority site. A total of three or four indicated a medium-priority site, and a total of five or six indicated a low-priority site. Sites further upstream were given preference for preliminary engineering investigations.

Biological value, which was determined by the Department of Fish and Game, was prioritized as follows:

| <u>Rating</u> | <u>Rating Definition</u>   |
|---------------|--|
| 1             | Project will have significant long-term benefits for salmon spawning and/or rearing.           |
| 2             | Project will have moderate long-term benefits for salmon spawning and/or rearing.              |
| 3             | Project will have relatively short-term or low long-term benefits for spawning and/or rearing. |

Engineering feasibility and cost, determined by the Department of Water Resources, were prioritized as follows:

Rating

Rating Definition

- |   |  |
|---|--|
| 1 | Project is technically feasible using proven methods in the basin; cost would be relatively low.           |
| 2 | Project is technically feasible; cost would be moderate.   |
| 3 | Project would involve complex design or application of unproven technology; cost would be relatively high. |

## RESTORATION

Four types of restoration were looked at: (1) restoration of salmon spawning riffles, (2) isolation of predator habitat, (3) improvement of the migratory path, and (4) enhancement of rearing habitat. Studies have shown that lack of spawning habitat and excess of predation are two of many factors limiting salmon production on the San Joaquin River system. Sites selected for restoration are primarily in the these two categories. However, each restoration design maximizes the habitat diversity potential of the individual site.

Restoration of salmon spawning riffles involves reshaping the channel to provide a predetermined depth, slope, and velocity. In addition, the gravel is either replaced or reconfigured for optimum use by salmon. A reshaped channel can include some or all of the following: resting pools, gravel point bars, terraces, and floodplains.

Rock weirs are sometimes used in a spawning reach to maintain grade, provide a drop in grade, or keep gravel from moving downstream in high flows. In addition, drop weirs allow flows through the gravel that provide oxygen to the eggs and wash away wastes and sediment. The weirs are constructed of large interlocking boulders placed in trenches perpendicular to the flow.

Isolation of predator habitat involves removing large, deep ponds containing warm, slow-moving water from the river active channel. Ponds of this type provide habitat for various fish species that prey upon out-migrating juvenile salmon. Generally the ponds are abandoned gravel mining pits with levees that have failed or are the result of major gold dredging operations. Restoration is accomplished by repairing the failed levee sections, improving existing levees to withstand high flow conditions, and directing the flow of the river away from the levees. Levee repair projects generally have a greater overall cost than construction of spawning riffles. However, greater benefits are also possible.

Improvement of the migratory path involves re-configuring the river to create meanders, resting pools, and a steady flow directed downstream. This steady flow is essential to directing out-migrating salmon smolts on their way to the ocean.

Enhancing rearing habitat requires the construction of areas for cover, resting and foraging.

## PRELIMINARY COST ESTIMATES

Preliminary engineering and designs were completed between fall 1992 and fall 1993. The preliminary designs and estimated costs for ten riffles on the Stanislaus, Tuolumne, and Merced Rivers are shown in Appendices A, B, and C, respectively. Cost estimates include mobilization and demobilization of equipment, excavation, placement, revegetation, materials, design, construction, and permitting.

The designs and estimates provided in this report will be submitted to the Department of Fish and Game. Several State and federal funding sources are available; however, the agreement between the Department of Fish and Game and the Department of Water Resources to offset fish losses in relation to the Harvey O. Banks Pumping Plant (Four Pumps Agreement) will be the primary source of funding.

Monitoring of restored sites will be done by the Department of Fish and Game under an existing program. The monitoring information will be used to improve design and construction techniques for future restoration sites. Monitoring costs are not included in the estimated cost figures.



## **SITE ASSESSMENTS AND SELECTIONS**

The assessments and selections of sites on the Stanislaus, Tuolumne, and Merced Rivers are presented below. Field studies of the sites were conducted from late 1992 through 1993.

### **Stanislaus River**

Nine potential salmon habitat restoration sites were identified on the Stanislaus River during field studies conducted in fall 1992. Site locations and river miles are shown on Figure 1. Approximately 20 miles of river were surveyed, from Knights Ferry to Jacob Meyers Park. Six sites are high priority. Estimated sizes, brief descriptions, and rankings are shown in Table 1.

Three sites were selected for preliminary engineering. These sites are representative of different types of restoration projects. Two gravel replacement projects and a channel reconfiguration are proposed. The preliminary engineering and costs are shown in Appendix A. The three remaining priority sites and their descriptions are shown in Appendix D.

### **Tuolumne River**

Approximately 26 miles of the Tuolumne River were surveyed, from La Grange Dam to Fox Grove. Sixteen potential salmon habitat restoration sites were located during surveys conducted in March 1993. All of the sites are spawning riffles. Site locations and river miles are shown on Figure 2. Seven sites are high priority. Estimated lengths, brief descriptions, and rankings are shown in Table 2. Channel widths vary from 75 to 100 feet wide, depending on location on the river and bank conditions. Preliminary engineering and designs have been completed on two sites and are outlined in Appendix B. The remaining five priority sites and their descriptions are shown in Appendix E.

Preliminary engineering is provided for Riffles 4A and 4B. Tim Ford, a biologist with the Turlock Irrigation District, and EA Engineering Consultants have stated that they consider restoration of Riffles 5A, 13A, and 13B greater priority than Riffles 4A and 4B. All five riffles are identified as high priority in this report.

### Merced River

Approximately 20 miles of the Merced River were surveyed, from the Crocker-Huffman Dam to Oakdale Road. Twenty-one potential salmon habitat restoration sites were located during surveys conducted in 1993. Site locations and river miles are shown on Figure 3. Estimated lengths, brief descriptions, and rankings are shown in Table 3. Ten of the 21 sites are high priority. Preliminary engineering and designs have been completed on two sites and are outlined in Appendix C. The remaining eight sites and their descriptions are shown in Appendix F.

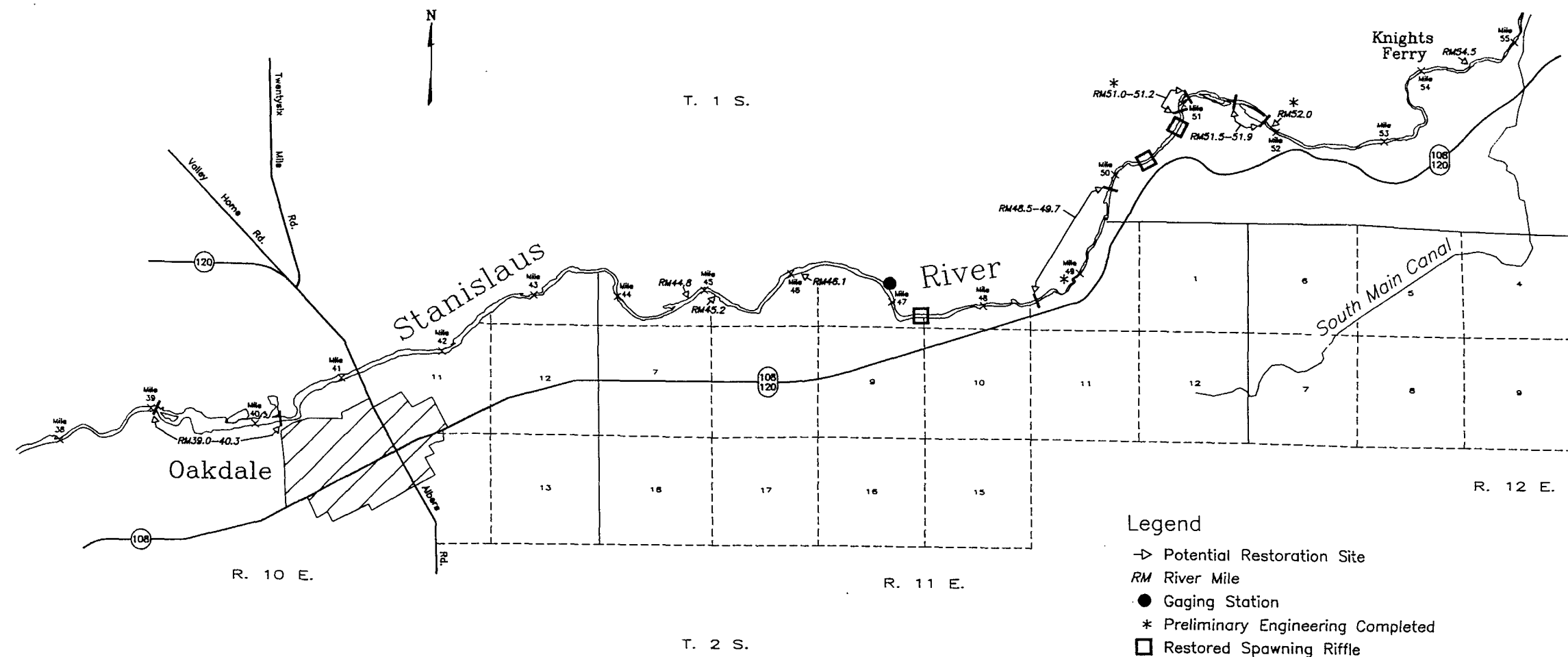


Figure 1. Stanislaus River, Salmon Habitat Assessment

TABLE 1

STANISLAUS RIVER  
POTENTIAL SALMON HABITAT IMPROVEMENT PROJECTS

| River Mile                | Site                    | Approximate Length or Area | Habitat Type | Site Description  | Project Description   | Rank (B+E)* |
|---------------------------|-------------------------|----------------------------|--------------|---|---|-------------|
| 54.5                      | Knights Ferry           | 50-75 feet                 | Spawning     | Low-cost project. Area is used by salmon.                                   | Enlarge spawning area. Use material on existing gravel bar to fill deep area of channel.                                      | 2+1         |
| 52.0**                    | Lover's Leap            | 300 feet                   | Spawning     | Currently lots of cobble and silt. Good shade, slope and access.            | Replace gravel.   | 1+1         |
| 51.6-51.9                 | Willms                  | 50 acres                   | Predator     | Breached levees. Flow passes through abandoned gravel pit.                  | Isolate predator habitat. Reconstruct approximately 1,500 feet of levee. Put river back into original channel and revegetate. | 1+1         |
| 51.0-51.2**               | Graupner                | 600 feet                   | Spawning     | Good riparian and drop. Opportunity for habitat diversity.                  | Clear side channel. Use existing gravel.  | 1+1         |
| 48.5-49.7,<br>48.8-48.9** | Honolulu Bar            | 5,000 feet                 | Spawning     | Opportunity for habitat diversity, riffle, pool, run sequence.              | Replace gravel. Block off south channel to increase flow in north channel.  | 1+1         |
| 46.1                      | Rodden Road             | 600-700 feet               | Spawning     | Long reach with good drop. Near areas used for salmon spawning and rearing. | Replace gravel.   | 1+2         |
| 45.2-45.3                 | Dillwood Road           | 300-400 feet               | Spawning     | Good drop. Low-cost project.  | Reconfigure channel. Use existing material on gravel bar.   | 1+1         |
| 44.7-44.9                 | Valley Oak              | 600-700 feet               | Spawning     | Good width, depth, velocity, and access.                                    | Replace gravel.   | 1+1         |
| 39.0-40.3                 | Oakdale Recreation Area | 150 acres                  | Predator     | Mosaic of abandoned gravel pits with breached levees.                       | Isolate predator habitat by reconstructing 2,500 feet of levee and revegetate. Major project.                                 | 2+3         |

\* B = biological value. E = engineering feasibility and cost.

\*\* Preliminary surveying, design, and engineering estimates are completed.

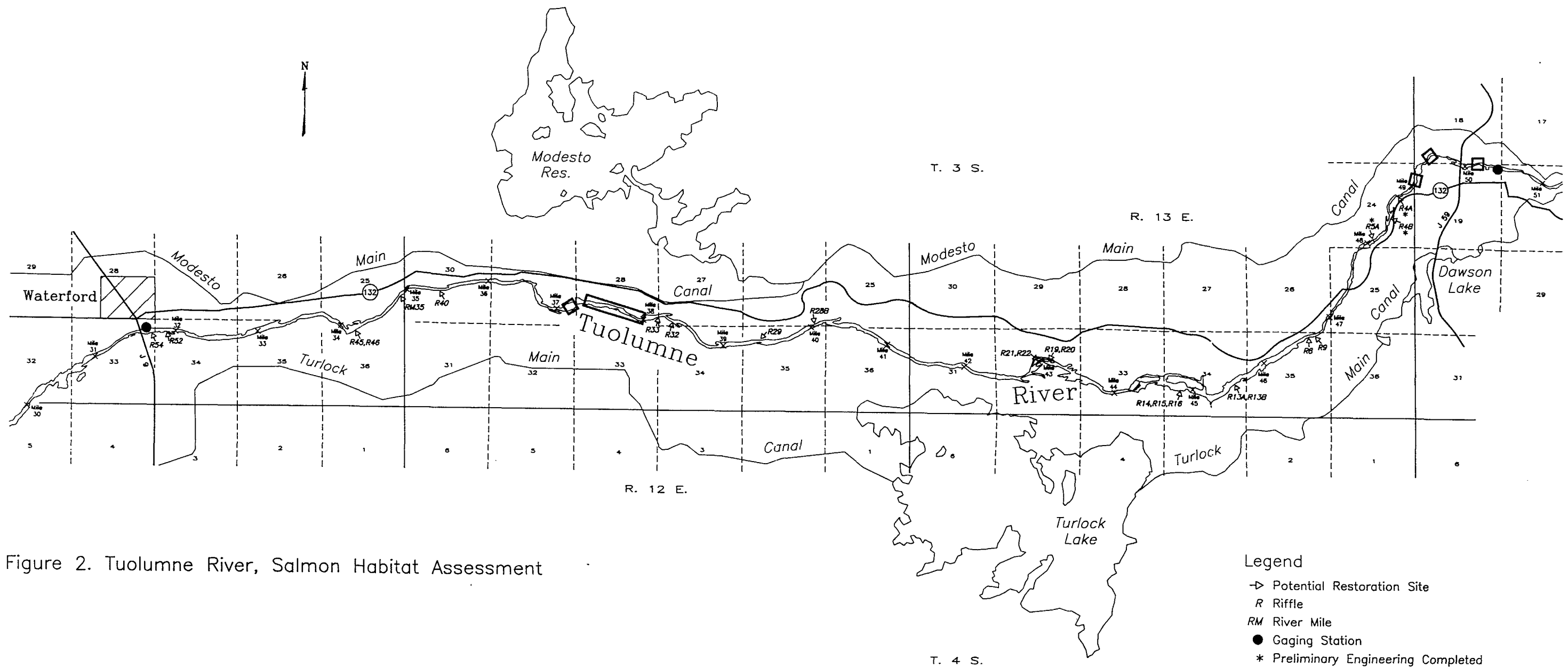


Figure 2. Tuolumne River, Salmon Habitat Assessment

TABLE 2

TUOLUMNE RIVER  
POTENTIAL SALMON HABITAT IMPROVEMENT PROJECTS

| River Mile | Riffle | Length (feet) | Habitat Type | Site Description  | Project Description  | Rank (B+E)* |
|------------|--------|---------------|--------------|---|--|-------------|
| 48.5       | 4A**   | 400           | Spawning     | Wide, shallow channel. Cobble substrate.                | Narrow channel using spoil material, remove cobble, add spawning gravel, and create diversity. | 1+1         |
| 48.0       | 4B**   | 400           | Spawning     | Vegetation encroachment. Slow velocity.                 | Re-engineer for variation, reduce width. Construction combined with 4A.                        | 1+1         |
| 47.5       | 5A     | 300           | Spawning     | Narrow, fast; large cobble, vegetation encroachment.    | Re-engineer and replace gravel.  | 1+1         |
| 46.5       | 8A&9   | 300-450       | Spawning     | Split flow. Cobble substrate.                           | Replace or rip gravel.   | 1+1         |
| 45.5-45.6  | 13A&B  | 600           | Spawning     | Split flow, deep channel on north, vegetation on south. | Spread drop over length. Replace gravel.   | 1+1         |
| 45.0-44.6  | 14-16  | 1,100         | Spawning     | Split flow, good diversity.                             | Re-engineer channel, replace gravel, and clear out vegetation.                                 | 2+2         |
| 43.4-43.0  | 19-22  | 700-1,000     | Spawning     | Split flow, good diversity.                             | Replace gravel and remove vegetation.  | 1+1         |
| 40.7       | 27     | 150-200       | Spawning     | Deep, fast, good drop.                                  | Replace gravel.  | 1+1         |
| 40         | 28     | 300           | Spawning     | Bedrock in middle.                                      | Remove vegetation.   | 2+1         |
| 39.7       | 29     | 400           | Spawning     | Good drop.  | Remove vegetation. Add terraces.   | 2+1         |
| 38.8       | 32     | 700-800       | Spawning     | Erosion on right bank.                                  | Move channel to left. Work with gravel operator.   | 2+2         |
| 38.6       | 33     | 500           | Spawning     | Split flow.   | Rechannelize. Replace gravel.  | 2+1         |
| 35.5       | 40     | 100-150       | Spawning     | Split flow, good drop.                                  | Enlarge island.  | 2+2         |
| 34.3-34.2  | 45&46  | 200-400       | Spawning     | Diverse habitat.  | Replace gravel.  | 2+2         |
| 33.2       | 52     | 200           | Spawning     | Poor access.  | Replace gravel.  | 3+2         |
| 31.8       | 54     | 400           | Migratory    | No flow in original channel.                            | Move river back to original channel.   | 3+3         |

\* B = biological value. E = engineering feasibility and cost.

\*\* Preliminary surveying, design, and engineering estimates completed.

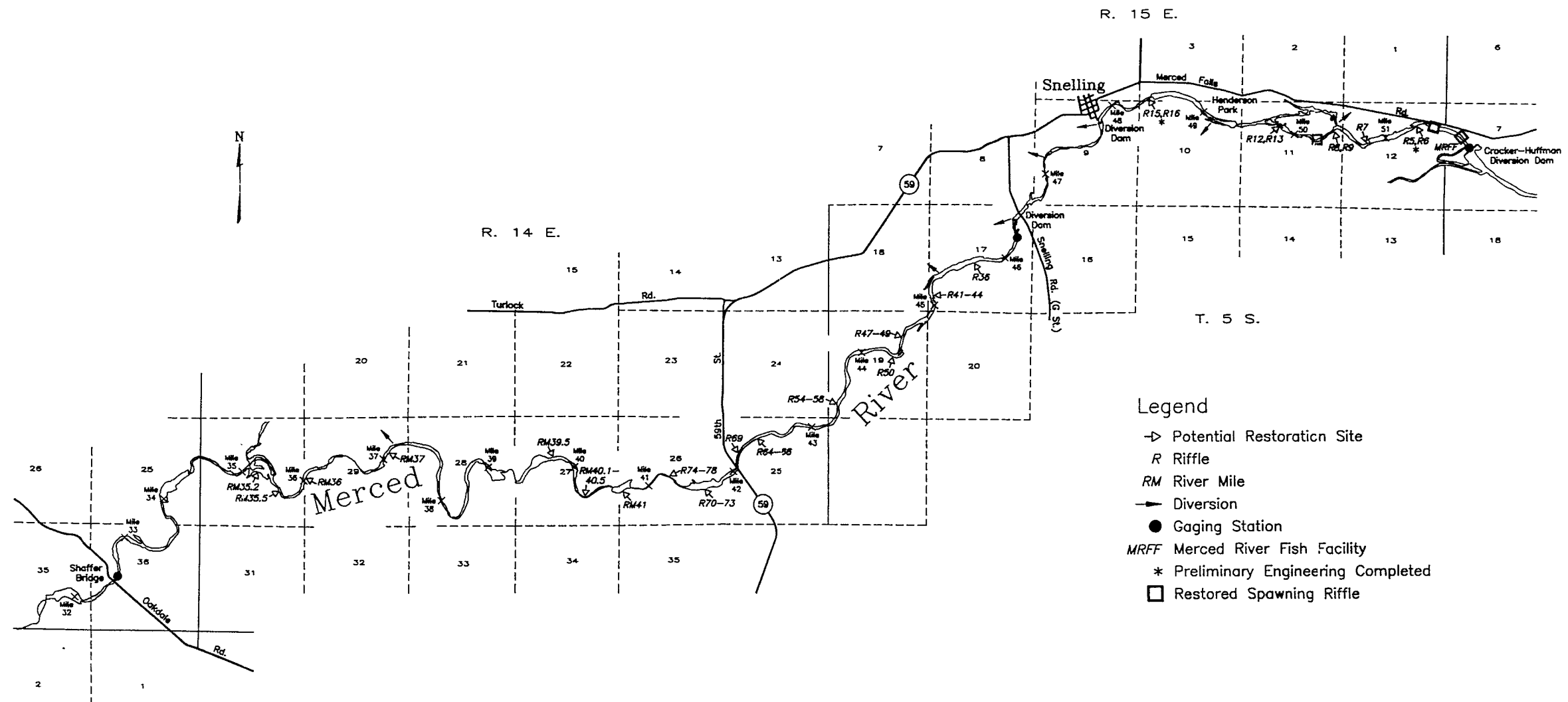


Figure 3. Merced River, Salmon Habitat Assessment

TABLE 3

MERCED RIVER  
POTENTIAL SALMON HABITAT IMPROVEMENT PROJECTS

| River Mile | Riffle | Approximate Length or Area | Habitat Type          | Site Description  | Project Description                                       | Rank (B+E)* |
|------------|--------|----------------------------|-----------------------|---|---|-------------|
| 51.4**     | 5&6    | 600 feet                   | Spawning              | Tall riparian on both sides. Good backwater area. Great drop and access.  | Replace gravel.   | 1+1         |
| 50.6       | 7&7A   | 300 feet                   | Spawning              | Vegetation on north side. Narrow. Poor access.  | Replace cobble and add drop structure.                    | 2+3         |
| 50.4       | 8      | 300 feet                   | Spawning              | Good overhanging riparian. Good access off Merced ID road on north side. Possible split flow. 1.5-to-2-foot drop. | Replace gravel (large armored cobble).                    | 1+1         |
| 49.9       | 12&13  | 400+400-foot split flow    | Spawning              | Good site. Combination of seven riffles over 700 to 800 feet. Access from dredger road on south.                  | Excavate substrate. Replace with spawning gravel.         | 1+1         |
| 48.4**     | 15&16  | 600 feet                   | Spawning              | Great site. 2-to-3-foot drop over length. Great access from north.  | Excavate substrate. Replace with spawning gravel.         | 1+1         |
| 46         | 36     | 100 feet                   | Spawning/<br>Predator | Side channel is choked with hyacinth.   | Repair breach and cut off side channel from main channel. | 2+1         |
| 45.5       | 41-44  | 700 feet                   | Spawning              | Great site. Concerns regarding cattle. Existing cobble. Good drop and velocity. Good access.                      | Replace gravel.   | 1+1         |
| 44.8       | 47-49  | 600 feet                   | Spawning              | Great site. Concerns regarding cattle. Existing cobble. Good drop and velocity. Good access.                      | Replace gravel.   | 1+1         |
| 44.5       | 50     | 500 feet                   | Spawning              | Great site. Concerns regarding cattle. Existing cobble. Good drop and velocity. Good access.                      | Replace gravel.   | 1+1         |
| 43.5       | 54-58  | 800 feet                   | Spawning              | Great site. Concerns regarding cattle. Existing cobble. Good drop and velocity. Good access.                      | Replace gravel.   | 1+1         |
| 42.7       | 64-66  | 800 feet                   | Spawning              | Good access. Cattle concerns.   | Replace gravel.   | 1+1         |



TABLE 3 (continued)

MERCED RIVER  
POTENTIAL SALMON HABITAT IMPROVEMENT PROJECTS

| River Mile | Riffle | Approximate Length or Area | Habitat Type           | Site Description   | Project Description   | Rank (B+E)* |
|------------|--------|----------------------------|------------------------|--|---|-------------|
| 42.1       | 69     | 200 feet                   | Spawning               | Great access.  | Rechannelize. Combine with Caltrans bridge protection funds.  | 3+1         |
| 41.5       | 74-78  | 600 feet                   | Spawning/<br>Migratory | Split flow. Hyacinth blocking south channel.   | Combine four gravel replacement projects with rechannelization. Possible elimination of erosion source. | 2+1         |
| 41.5       |        |                            | Predator               | Large pools in flow path. Need historic photos to determine original channel location. | Locate and repair levees. Create channel.   | 2+3         |
| 40.1-40.5  |        | 2,500 feet<br>200 acres    | Predator               | Huge ponds. Potentially significant benefits.  | Minimal levee repair relative to benefits.  | 1+1         |
| 39.8       | 70-73  | 550 feet                   | Spawning               | Good access.   | Combine three sites. Replace gravel. Repair side channel.   | 2+1         |
| 39.5       |        | 400 feet                   | Spawning               | Good access. Riparian on north bank.   | Replace gravel.   | 2+1         |
| 37-37.1    |        | 450 feet                   | Spawning               | Good site. Good access.  | Replace gravel. Combine 150-foot riffle with 300-foot riffle.   | 2+1         |
| 36         |        | 400 feet                   | Spawning               | Good site. Good access. Narrow. Good vegetation.                                       | Could be widened.   | 2+2         |
| 35.5       |        | 400 feet                   | Spawning               | Dirty gravel. Good access.   | Needs to be ripped.   | 3+1         |
| 35.2       |        | 150 feet<br>20 acres       | Predator/<br>Migratory | Flows exit channel through small diversion into a large pool.                          | Isolate pond. Minimal length of repair for large benefit.   | 2+1         |

\* B = biological value. E = engineering feasibility and cost.

\*\* Preliminary surveying, design, and engineering estimates completed.

## BIBLIOGRAPHY

California Department of Fish and Game. *California Salmonid Stream Habitat Restoration Manual*. August 1991.

\_\_\_\_\_. *Central Valley Salmon and Steelhead Restoration and Enhancement Plan*. April 1990. .

\_\_\_\_\_. *Restoring Central Valley Streams: A Plan for Action*. November 1993.

**APPENDIX A**  
**STANISLAUS RIVER PRELIMINARY DESIGNS**

**Stanislaus River  
River Mile 52  
Lover's Leap**

This site has a lot of potential for salmon spawning riffle. It has good slope and width and good access from the north bank. There is plenty of riparian vegetation to provide shade, cover, and food. A resting pool exists immediately downstream from the riffle.

The current substrate is large cobble, laden with silt. Restoration will involve excavating the channel and replacing the substrate with washed, graded spawning gravel. Three control structures will be used to maintain grade.

The restored site will be approximately 100 feet wide and 400 feet long. Approximately 4,500 square feet of spawning gravel would be available after restoration.

The restoration is roughly estimated to cost \$85,000 and take three weeks to construct. No significant permitting issues are seen at this time.



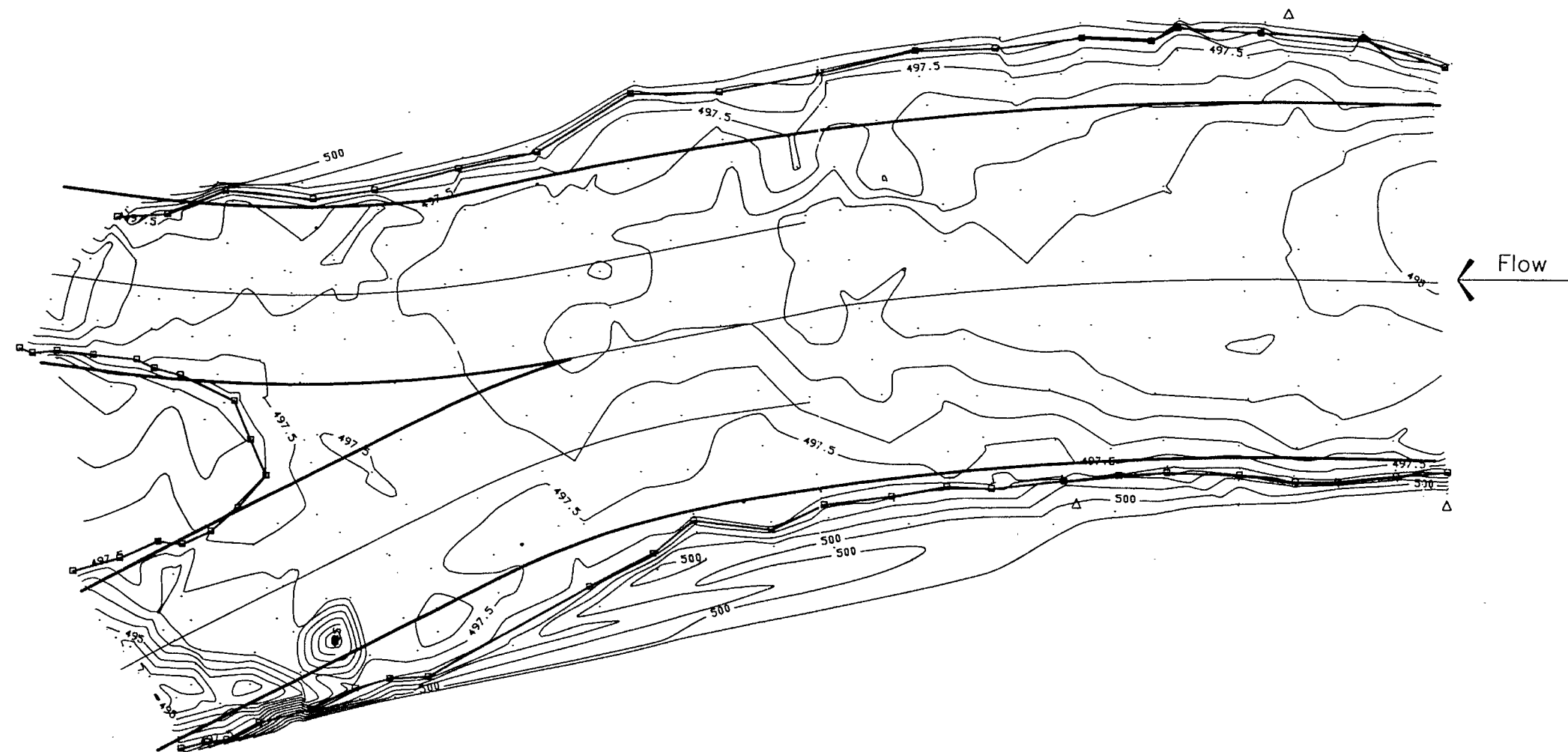
Stanislaus River, Lover's Leap.  
View looking downstream.



Stanislaus River, Mile 52.0, Lover's Leap.  
View looking upstream.



Stanislaus River, Mile 52.0, Lover's Leap.  
Existing substrate.



N  
 Contour Interval = 0.5'

- Legend
- Waters Edge
  - Proposed Channel
  - △ Control Point

Stanislaus River Mile 52.0, Preliminary Design

DWR/SJD Jan. 1994      Prepared by K. Faulkenberry      Drawn by K. Winden

**Stanislaus River  
Mile 51.2  
Graupner**

This site was used historically by spawning salmon. The channel is split. The substrate in the side channel is good for spawning purposes, but it has become choked with vegetation and flow velocities are too slow for spawning use by salmon. A pool-riffle-pool-riffle sequence is proposed for the side channel. The main channel has a good drop for constructing a riffle and an existing large pool for resting.

The site has good access from the north bank. There is plenty of riparian vegetation to provide shade, cover, and food. The island separating the two channels will be preserved for its habitat and hydrologic value.

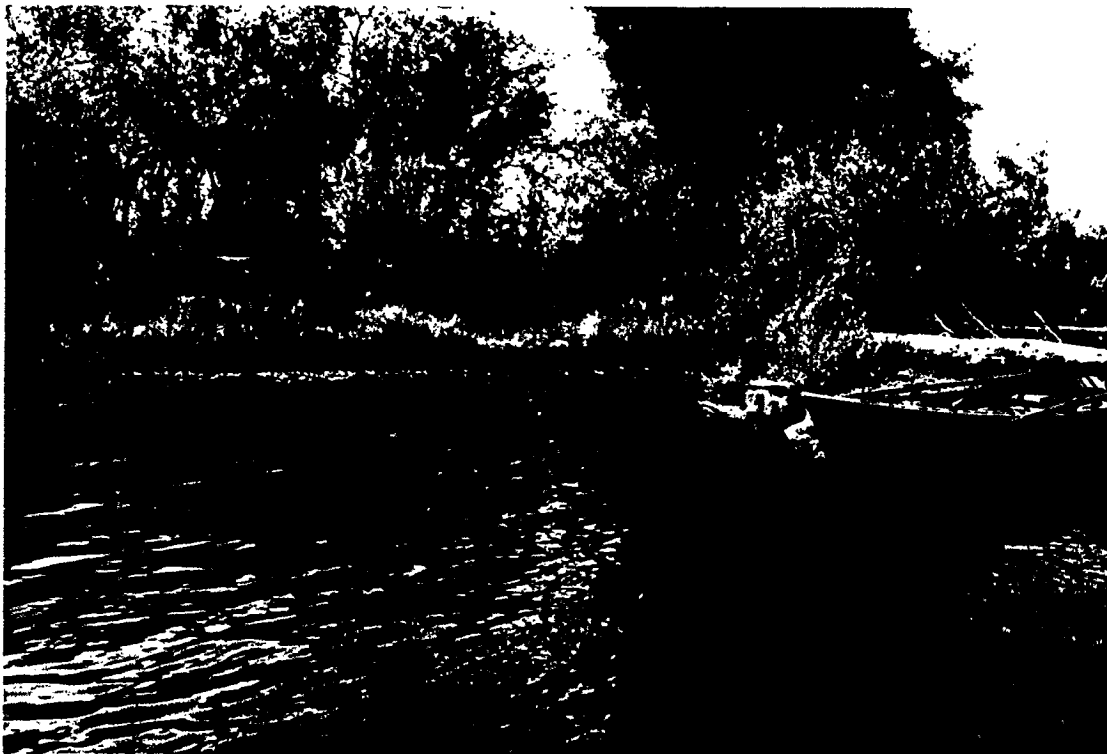
Restoration will involve cleaning out the side channel, excavating the main channel, and replacing the substrate with washed, graded spawning gravel. Seven control structures will be used to maintain grade -- two in the side channel and five in the main channel.

The restored side channel will be approximately 30 feet wide and 800 feet long. The restored main channel will be approximately 70 feet wide and 300 feet long. Approximately 4,000 square yards of spawning gravel will be available after restoration.

The restoration is roughly estimated to cost \$81,000 and take four weeks to construct. No significant permitting issues are seen at this time.



Stanislaus River, Mile 51.2, Graupner.  
View from main channel pool toward side channel.



Stanislaus River, Mile 51.2, Graupner.  
View toward main channel from upstream end.



Stanislaus River, Mile 51.2, Graupner.  
View toward down channel from upstream end.





Stanislaus River Mile 51.2, Preliminary Design

DWR/SJD      Prepared by      Drawn by  
Jan. 1994      K. Faulkenberry      K. Winden

**Stanislaus River  
Mile 48.8-48.9  
Honolulu Bar**

The reach of river from Mile 48.5 to Mile 49.7 (shown below) contains a variety of potential restoration projects and diversity of habitat. The reach has good drop to create the velocities necessary for spawning riffles. Some areas need the substrate replaced, some need widening, and some need the side channel excluded from the main flow.

Two riffles at Mile 48.8 and 48.9 were surveyed. Restoration of these riffles will involve excavating the channel and replacing the substrate with washed, graded spawning gravel. The sites will be designed and constructed as one job. Two control structures will be used to maintain grade.

The site has good slope and width, and good access from the north bank. There is plenty of riparian vegetation to provide shade, cover and food.

The current substrate is large cobble, laden with silt. The restored site will be approximately 80 feet wide and 950 feet long. Approximately 8,400 square yards of spawning gravel will be available after restoration.

The restoration is roughly estimated to cost \$140,000 and take four weeks to construct. No significant permitting issues are seen at this time.



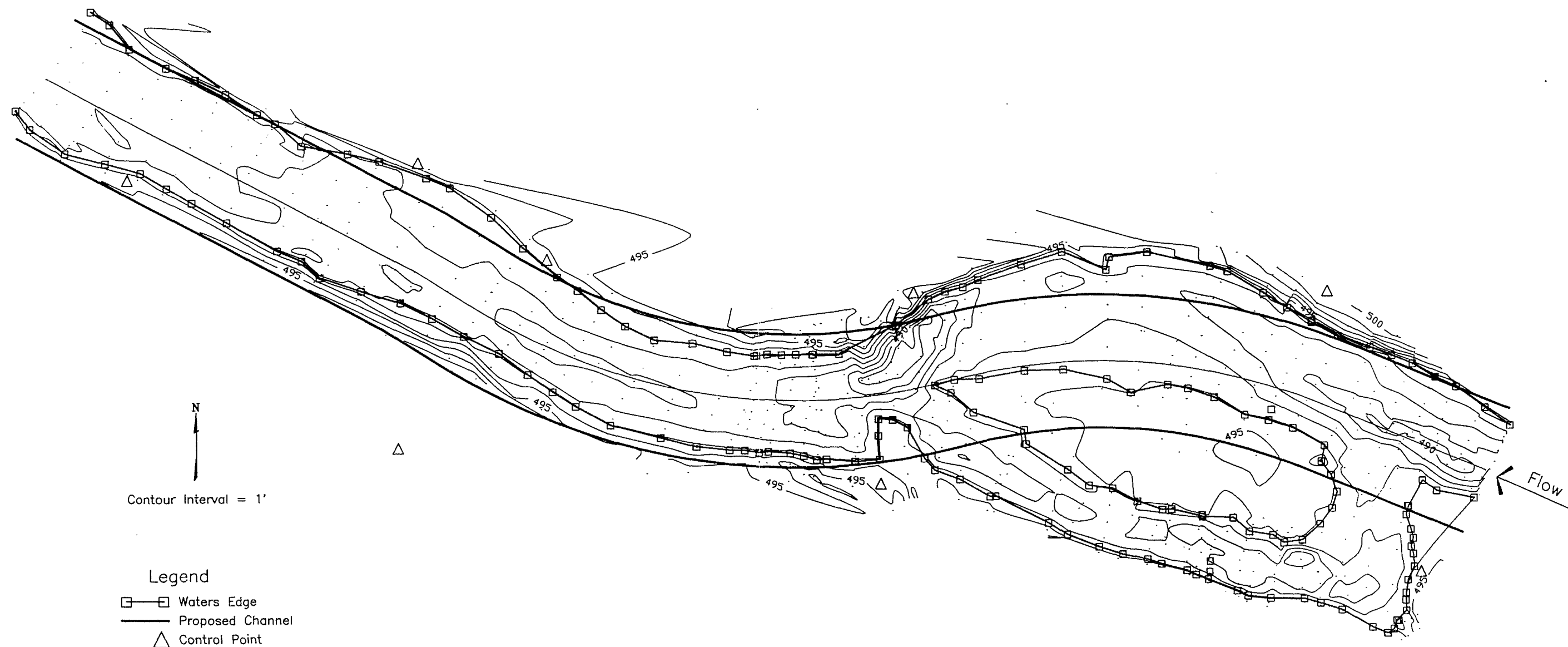
Stanislaus River, Mile 48.8, Honolulu Bar.  
View looking downstream.



Stanislaus River, Mile 48.9, Honolulu Bar.  
Bottom of Mile 48.9 looking upstream.



Stanislaus River, Mile 48.9, Honolulu Bar.  
Left side channel looking upstream.



Stanislaus River Mile 48.8 & 48.9, Preliminary Design

DWR/SJD  
Jan. 1994

Prepared by  
K. Faulkenberry

Drawn by  
K. Winden

**APPENDIX B**  
**TUOLUMNE RIVER PRELIMINARY DESIGNS**

**Tuolumne River  
Mile 48.5  
Riffle 4A**

This site has good slope but is very wide and shallow. There is good access from the north bank. There is an opportunity to create an undulating channel bottom similar to heavily used spawning areas immediately upstream.

The current substrate is large cobble, laden with silt. Restoration will involve excavating the channel and replacing the substrate with washed, graded spawning gravel. The excavated material will be used to move in the banks and increase velocities by making the channel narrower. Two control structures will be used to maintain grade.

The restored site will be approximately 100 feet wide and 880 feet long. Approximately 4,900 square yards of spawning gravel will be available after restoration.

The restoration is roughly estimated to cost \$172,000 and take four weeks to construct. No significant permitting issues are seen at this time.



**Tuolumne River, Mile 48.5, Riffle 4A.  
Right bank looking upstream.**



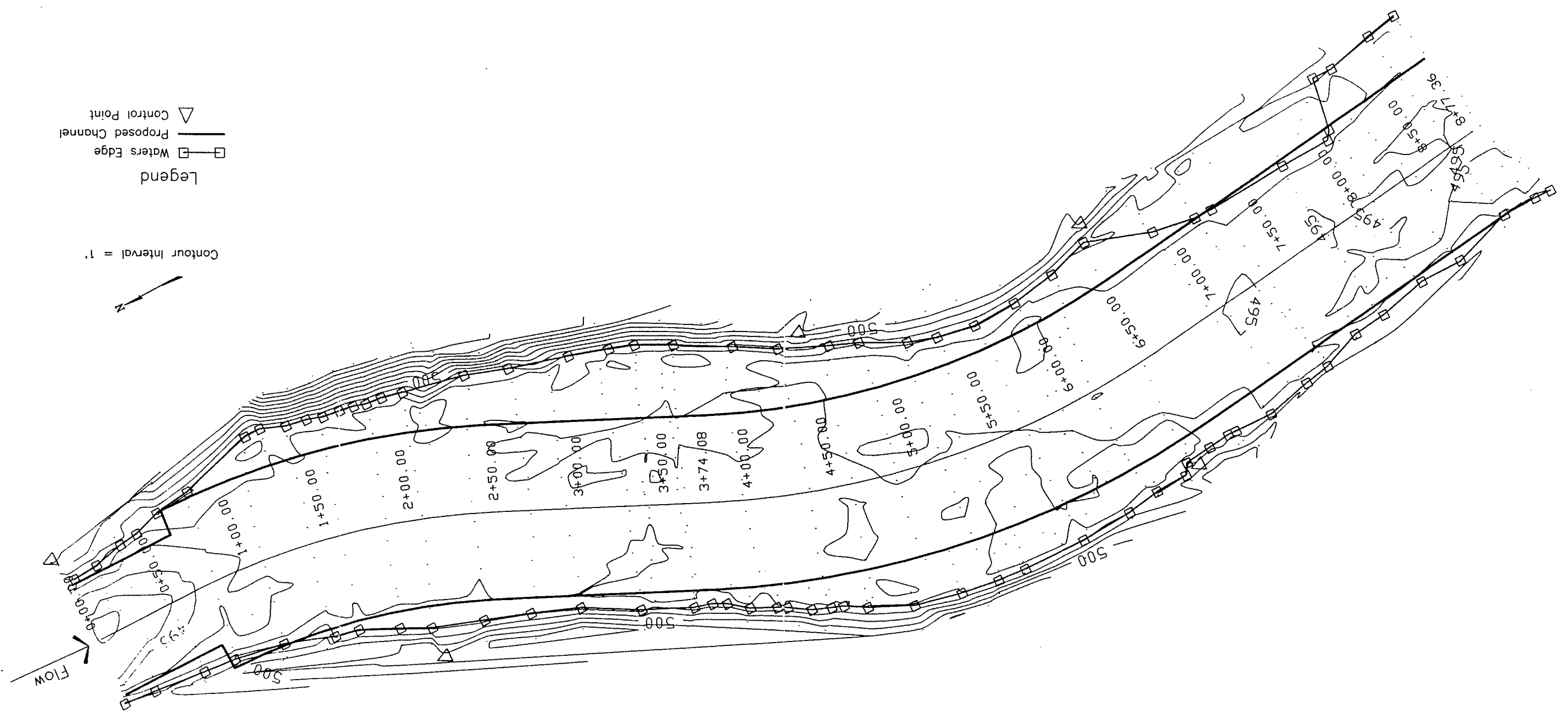
Tuolumne River, Mile 48.5, Riffle 4A.  
Right bank looking downstream.



Tuolumne River, Mile 48.5, Riffle 4A.  
Left bank looking downstream.

DWR/SJD  
Jan. 1994  
Prepared by K. Raukenberry  
Drawn by K. Winden

Tuolumne River Riffle 4A, Preliminary Design



D-020962



**Tuolumne River  
Mile 48.0  
Riffle 4B**

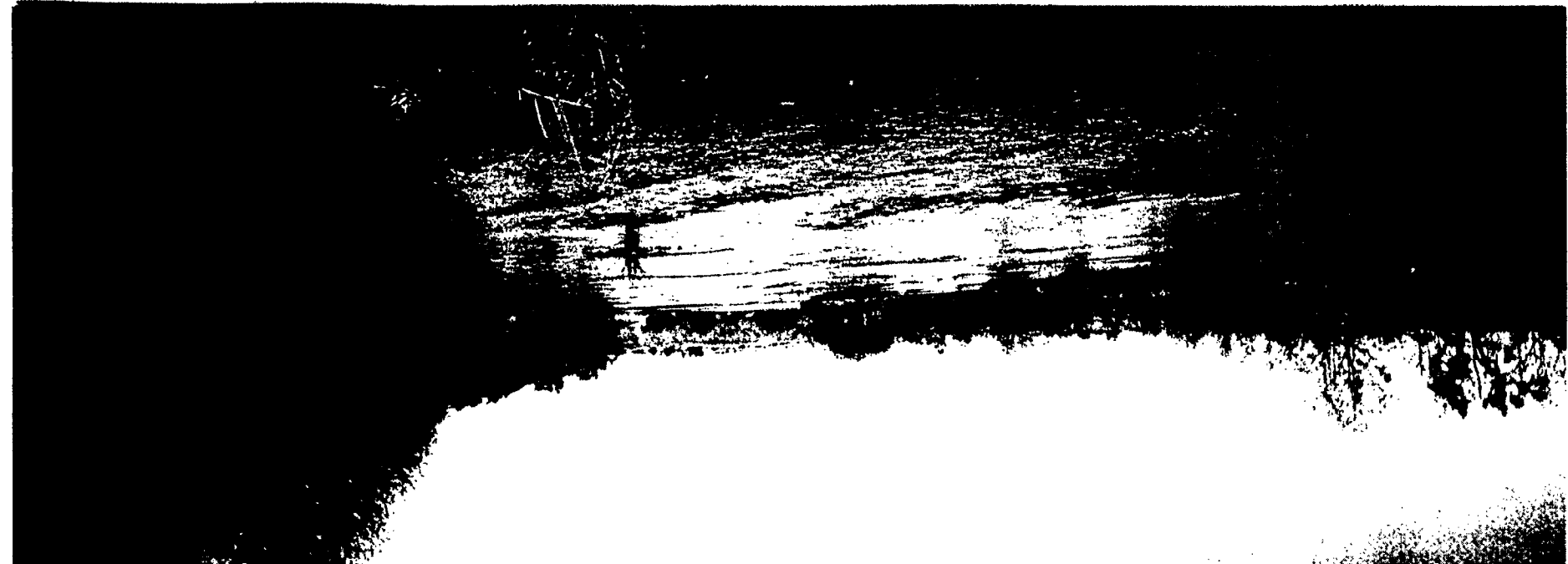
The gravel at this site was experimentally cleaned in spring 1991. It has already silted, and lots of vegetation has encroached into the channel. The riffle is very wide and shallow.

This site has good slope but is very wide and shallow. There is good access from the north bank. There is an opportunity to create an undulating channel bottom similar to heavily used spawning areas immediately upstream.

The current substrate is large cobble, laden with silt. Restoration will involve excavating the channel and replacing the substrate with washed, graded spawning gravel. The excavated material will be used to move in the banks and increase velocities by making the channel narrower. Two control structures will be used to maintain grade.

The restored site will be approximately 100 feet wide and 680 feet long. Approximately 7,600 square yards of spawning gravel will be available after restoration.

The restoration is roughly estimated to cost \$135,000 and take four weeks to construct. No significant permitting issues are seen at this time.

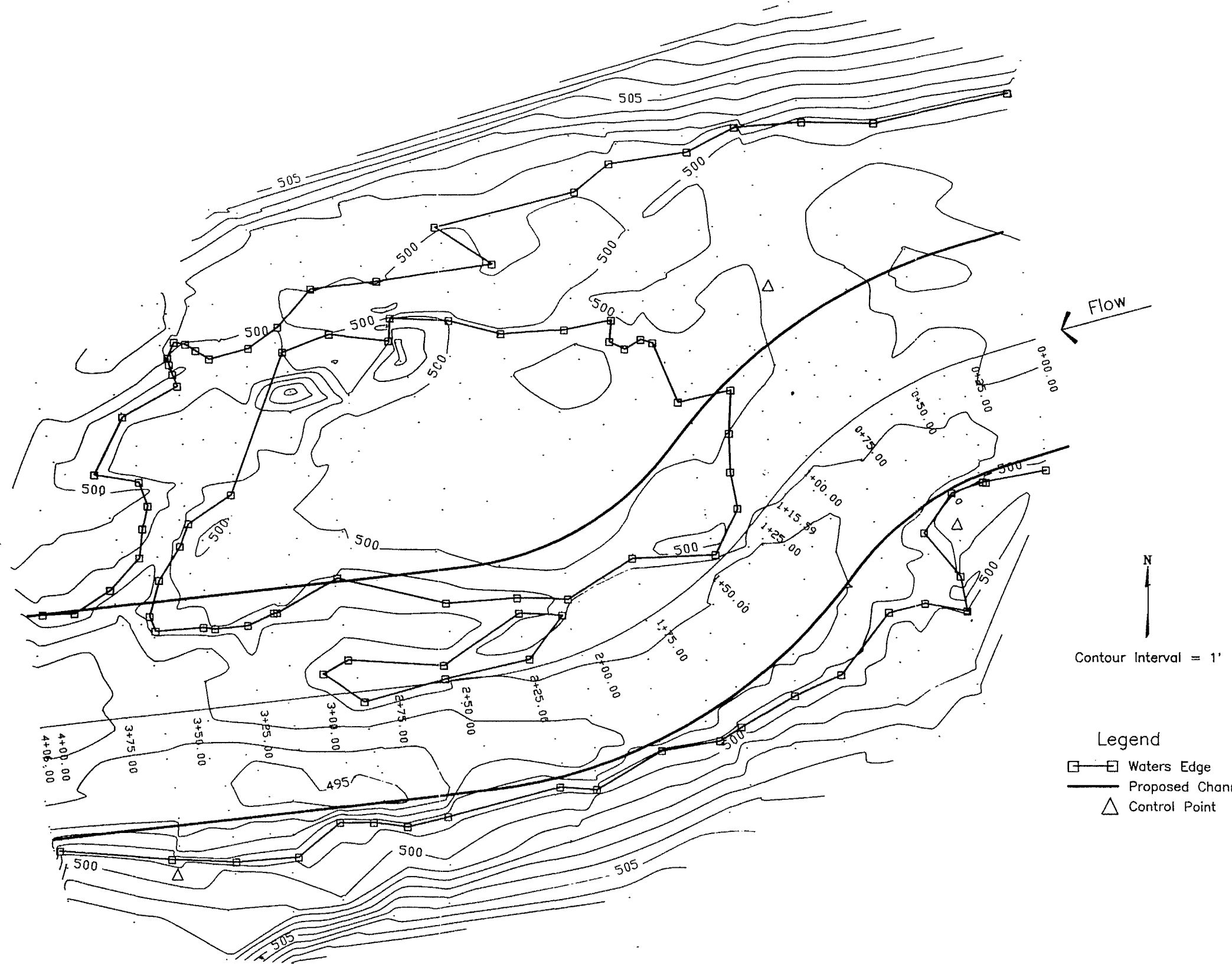


Tuolumne River, Mile 48.0, Riffle 4B





**APPENDIX C**  
**MERCED RIVER PRELIMINARY DESIGNS**



Merced River Riffles 5 & 6, Preliminary Design

DWR/SJD  
Jan. 1994

Prepared by  
K. Faulkenberry

Drawn by  
K. Winden

**Merced River  
Mile 48.4  
Riffles 15, 16A, and 16B**

These riffles occur on both sides of a small island and immediately downstream of a riparian diversion.

This site has a steep slope that will be reduced through the use of drop structures. The site has good riparian vegetation and easy access off of Merced Falls Road on the north.

The current substrate is large cobble, laden with silt. Restoration will involve excavating the channel and replacing the substrate with washed, graded spawning gravel. Two drop structures and one control structure will be used to maintain grade and create habitat variation.

The restored site will be approximately 100 feet wide and 360 feet long. Approximately 4,000 square yards of spawning gravel will be available after restoration.

The restoration is roughly estimated to cost \$91,000 and take three weeks to construct. No significant permitting issues are seen at this time.



Merced River, Mile 48.4, Riffles 15 and 16.  
South channel below curve, looking downstream.



Merced River, Mile 48.4, Riffles 15 and 16.  
North channel looking downstream.



Merced River, Mile 48.4, Riffles 15 and 16.  
South channel looking downstream.



Merced River Riffles 15 & 16, Preliminary Design

N  
 Contour Interval = 1'

- Legend
- Waters Edge
  - Proposed Channel
  - △ Control Point

DWR/SJD      Prepared by      Drawn by  
 Jan. 1994      K. Faulkenberry      K. Winden



**APPENDIX D**  
**STANISLAUS RIVER PRIORITY SITES**

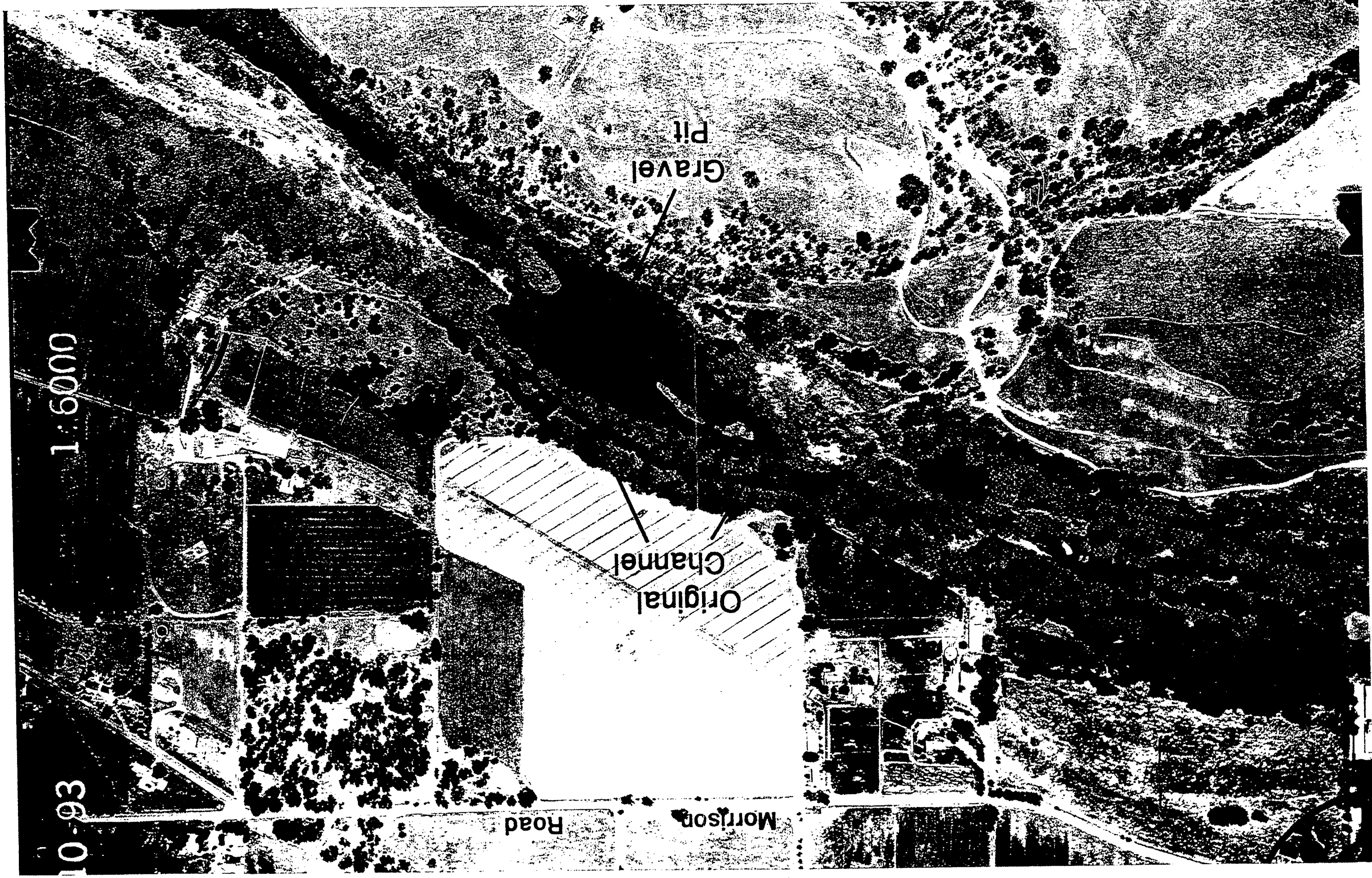
**Stanislaus River  
Mile 51.6-51.9  
Willms**

At this site a levee has breached and the river now flows through an abandoned gravel pit. The original channel, on the north side, still has significant flows. The pit is approximately 50 acres. It provides habitat for predators of out-migrating salmon smolts.

Repairs to the breaches in the levee are relatively minor in comparison to the large amount of predator habitat that could be isolated from the river channel. There is excellent riparian habitat on both sides of the original channel that would be preserved during and after construction.

This is a very high priority site. The actual construction costs will be minor compared to the benefits. However, the cost of preliminary engineering will be significant due to the size of the site, the dense vegetation, and the depth of the water.

The site has good access from both sides. The landowner on the north side has expressed a willingness to have work go forward.



0009:1

36-01

**Stanislaus River**  
**Miles 45.2-45.3 and 44.7-44.9**  
**Dillwood Road and Valley Oak**

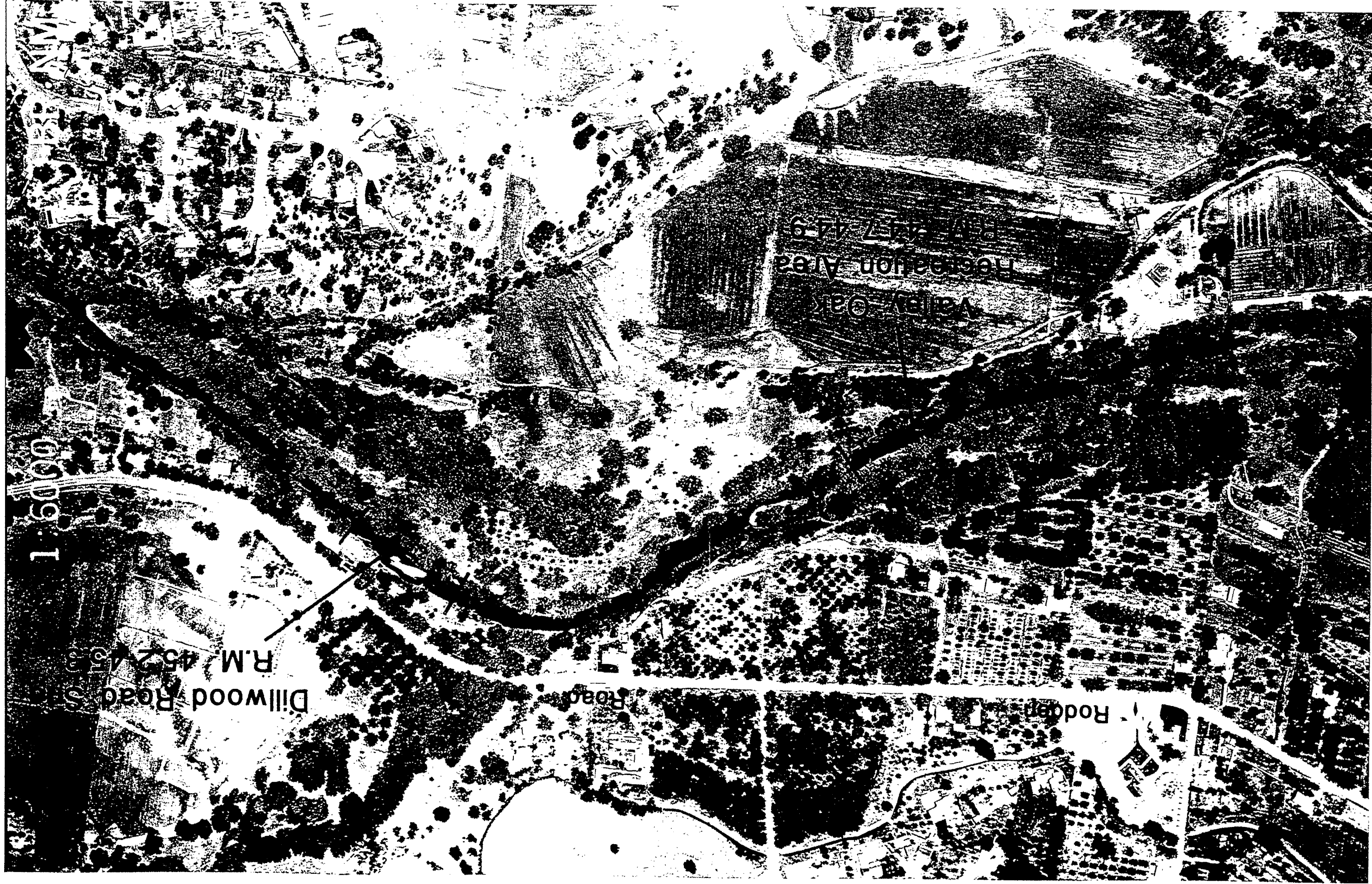
Restoration of Dillwood Road site (Mile 45.2-45.3) would produce significant benefits at minimal cost. In the channel there are two gravel bars consisting of good spawning-size gravel. The material in these bars could be redistributed in the channel and made accessible to the salmon.

The site is between 300 and 400 feet long and has good drop for the creation of spawning velocities. There is good access from the north bank at the downstream end of the site. This site could be constructed in conjunction with the Valley Oak site immediately downstream.

The existing gravel at the Valley Oak site is too small and is silted in. The existing gravel would be excavated out and replaced with graded and washed spawning gravel. The site has good potential for restoration based on adequate width, drop, and length (600-700 feet). There is a pool at the downstream end to provide resting habitat. The site has good access across U.S. Corps of Engineers property on the north side.

Poaching could be a problem at this site. It is adjacent to the Corps' Valley Oak Recreation Area, a public use facility.

Stanislaus River, Valley Oak Recreation Area and Dillwood Road Site



D-020975

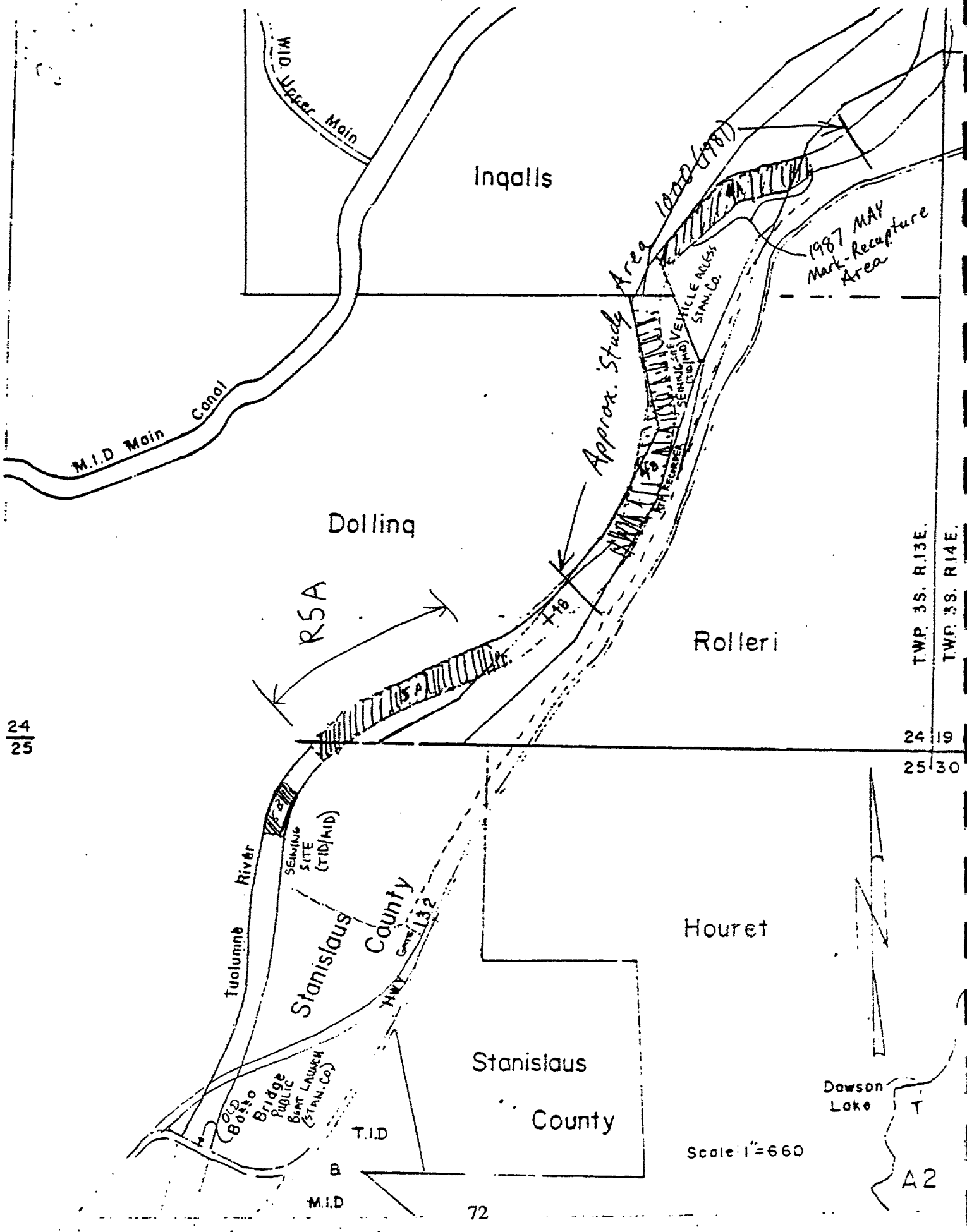
D-020975

**APPENDIX E**  
**TUOLUMNE RIVER PRIORITY SITES**

**Tuolumne River  
Mile 47.5  
Riffle 5A**

At this site the channel is narrow, vegetation has encroached into the channel, and the velocities are high. The substrate is large cobble. Spawning conditions at the site could be improved by excavating the cobble and replacing it with graded, washed spawning gravel. Velocities could be improved by either creating a split flow channel or by constructing gravel bars. The site has good access from the south side.

The potential for salmon use is good at this location based on historic use and on use immediately upstream and downstream of the site.





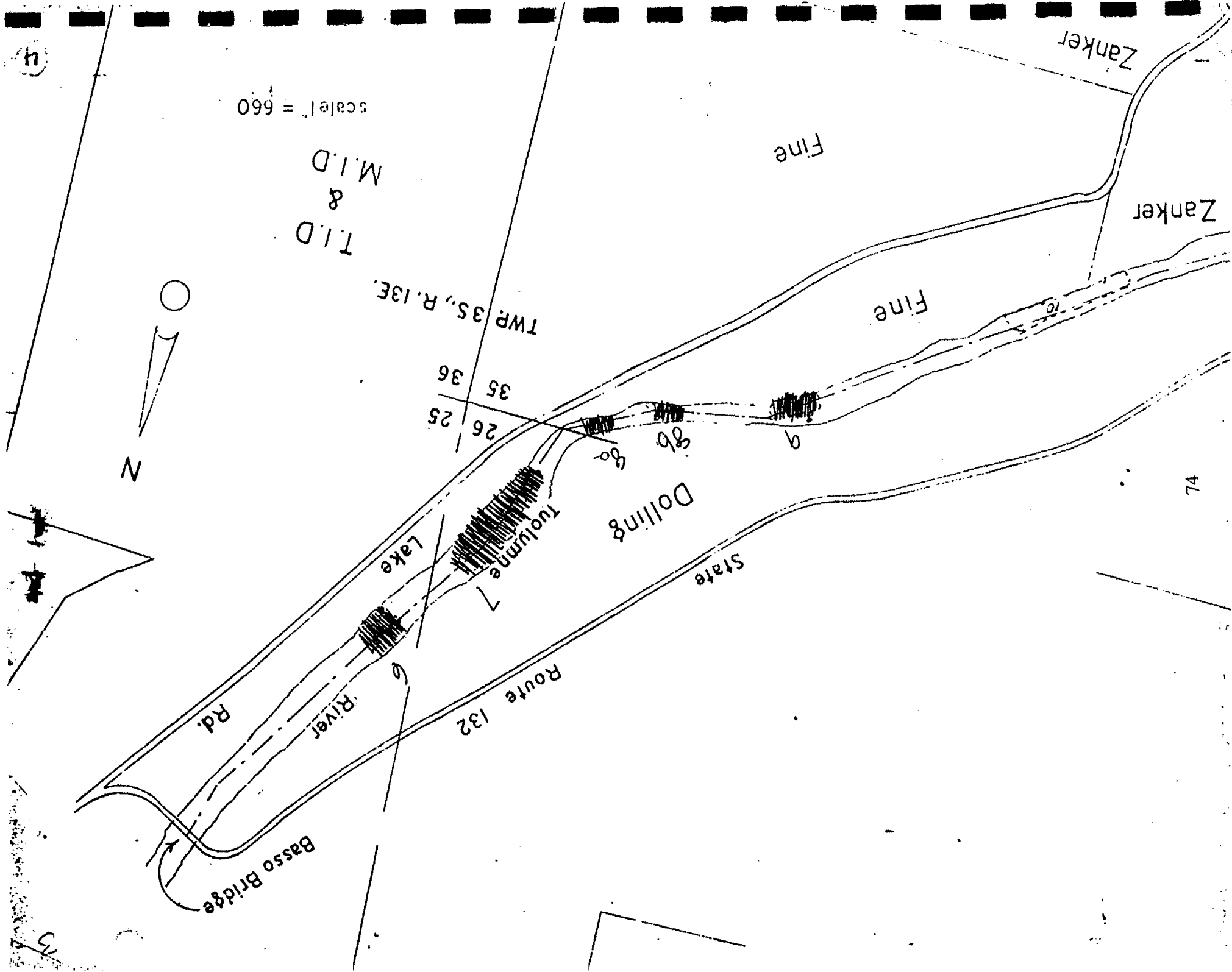
**Tuolumne River  
Mile 46.5  
Riffles 8A and 9**

The upstream site, Riffle 8A, has a split flow with cobble in the left channel and lots of spawning use in the right channel. The site has good drop and diversity. It is relatively small -- less than 150 feet long. Restoration could involve a gravel replacement in the left channel or removal of the island and encroached vegetation. Restoration could provide spawning benefits but would need to be constructed in combination with another site to be cost-effective.

Riffle 9 would be beneficial and cost-effective in combination with the construction of Riffle 8. The riffle is about 300 feet long, with good drop and velocities. The gravel at this site is fairly good size and mix for spawning; however, it is silted in. The gravel could be ripped and freed for spawning use.

Both Riffles 8A and 9 have good access off of Lake Road on the south side.

D-020980



74

Zanker

Zanker

Fine

Fine

State

Dolling

Route 132

Tuolumne

Lake

River

Basso Bridge

N

T.I.D. & M.I.D.

scale 1" = 660

Twp 35, R. 13E

25 26 35 36

80 86 9

10

u

D-020980

**Tuolumne River  
Mile 45.5  
Riffles 13A and 13B**

The channel is split at Riffles 13A and 13B. There is a deep channel on the north and vegetation encroachment on the south channel. The overall site is approximately 600 feet long. There is good drop and good vegetation. There is a lot of potential to create diversity at this location. The site is easily accessed from the north off of State Route 132.

|    |    |
|----|----|
| 33 | 34 |
| 4  | 3  |

Daniels

Rairden

fuelumhe

Zanker

Dolling

Zanker

Dolling

Route 132

State

Split  
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walk left

scale 1" = 660

TWP 35, R13E.



Rd.

Lake

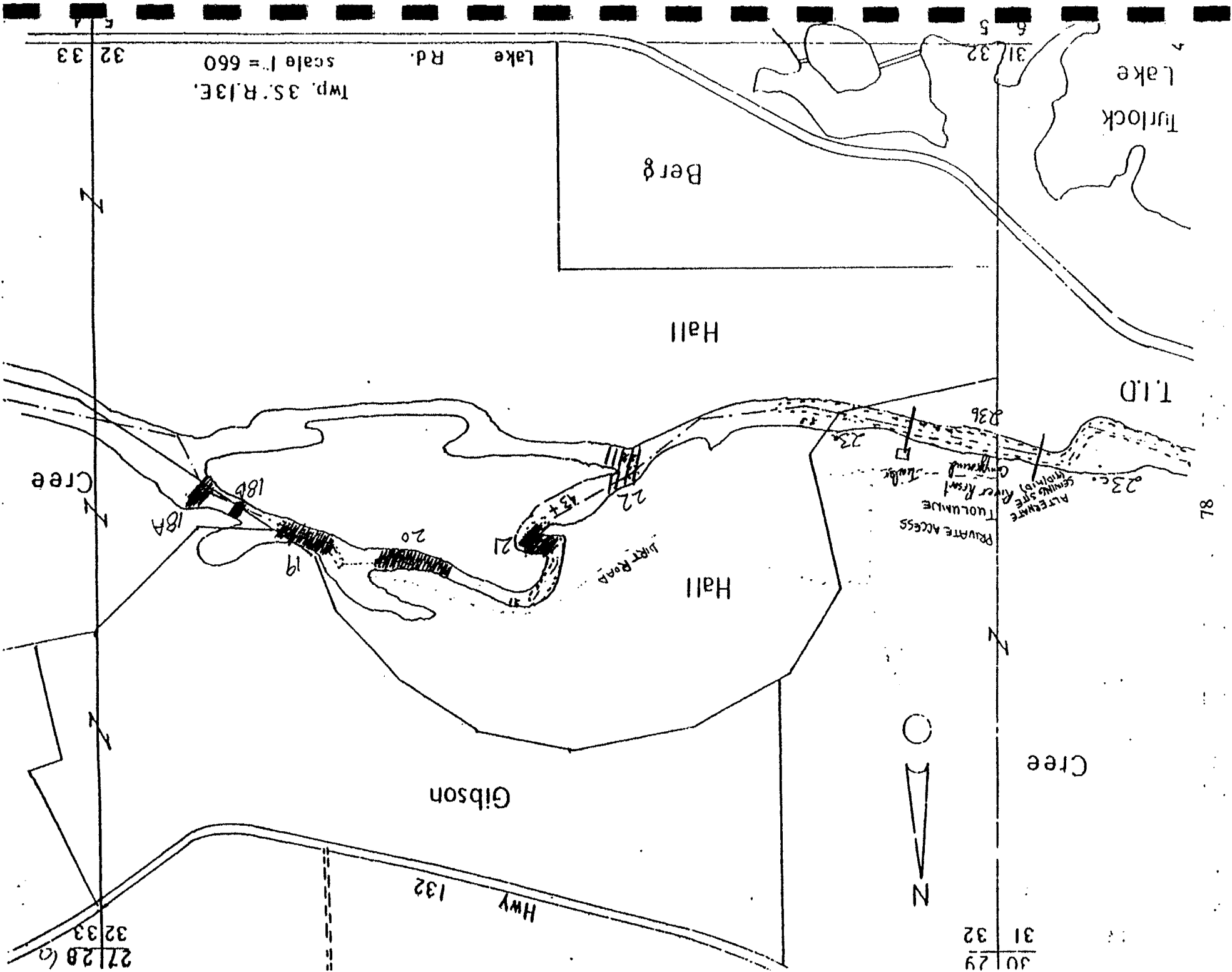
D-020982

D-020982

**Tuolumne River**  
**Mile 43.0-43.4**  
**Riffles 19-22**

Four riffles exist in a reach of river approximately 1,000 feet long. The river is split at this location and there is significant vegetation encroachment into the channel.

Riffles 19, 20, 21, and 22 could be restored to improve spawning use. Cobble at Riffle 19 could be excavated and replaced with graded, washed spawning gravel. The gravel at Riffles 21 and 22 may only need to be cleaned by ripping. There is good drop over the entire reach and lots of opportunities for creating habitat diversity. The reach is easily accessed off of Highway 132 on the north.



D-020984

D-020984

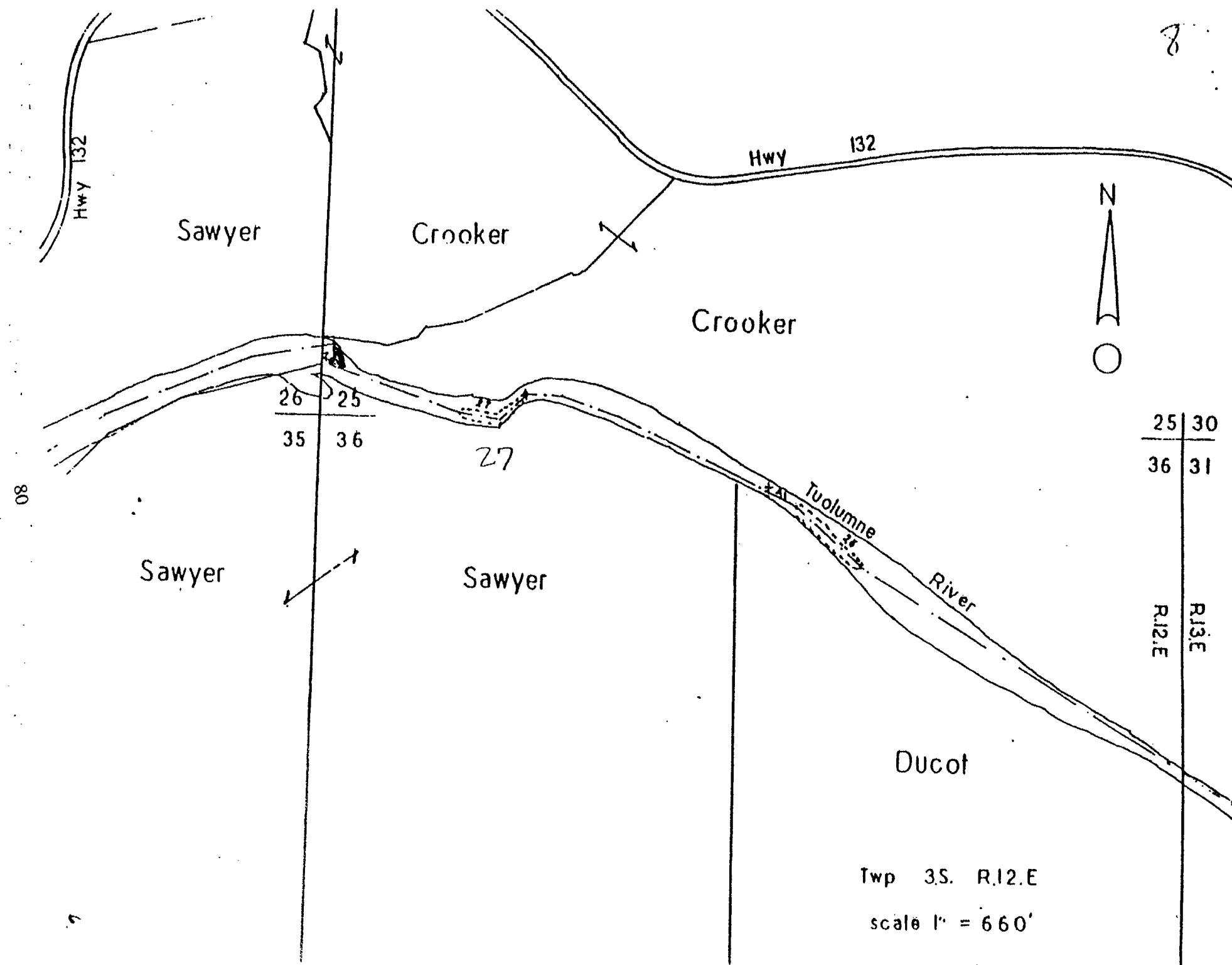
**Tuolumne River**  
**Mile 40.7**  
**Riffle 27**

The river makes a 90-degree turn at Riffle 27. There is a rock dam at the head of the riffle making it too deep and fast for spawning. Restoration could involve removing the dam and spreading the drop over the 200-foot reach. The gravel in this riffle also needs to be replaced.

Restoration efforts may be short lived at this location due to the impacts from the sharp turn in the river. Any restoration designs should address how to minimize the impacts of this turn.

The site is easily accessed off of Highway 132 on the north.

8



D-020986



**APPENDIX F**  
**MERCED RIVER PRIORITY SITES**

**Merced River  
Mile 50.4  
Riffle 8**

There is a split flow and a diversion structure at this site. The substrate is large, armored cobble. The site is approximately 300 feet long and 75 feet wide, with a drop of 1.5 to 2 feet. There is good overhanging riparian vegetation along the banks and easy access off of Merced Irrigation District road on the north.

Restoration would involve excavating the substrate and replacing it with graded, washed spawning gravel.

CLEARED  
FIELD

CUNEO  
FISHING  
ACCESS

DIVERSION

DREDGER

## OVERHANGING TREES

## TAILINGS

MAURICE  
CALLED  
SECTION  
"THE WHITE"

RG

296

29A

LONG

TREE  
WITH  
SWING  
ROPE

TAILINGS

NEW GRAVEL  
ADDED  
IN 1991

LOG

OVERHANGING TREE

~~CALM WATER~~

**FALSE**  
**LOG**

DREDGER TAILINGS

EATING  
TREE

FALLEN  
TREES

BILADEN  
FARM  
SIN

34

**D - 0 2 0 9 8 9**

D-020989

**Merced River**  
**Mile 49.9**  
**Riffles 12A, 12B, 13A, 13B, and 13C**

There are two islands in the channel at this location. The hydrology at this site provides ample opportunities to create habitat diversity. Restoration would involve excavating the substrate and replacing it with graded, washed spawning gravel. Riffles 13X and 13Y in the north channel are used by spawning salmon. No restoration of these two riffles is proposed.

The site is approximately 800 feet long altogether. The site has good access from dredger roads on the south side.

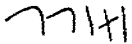


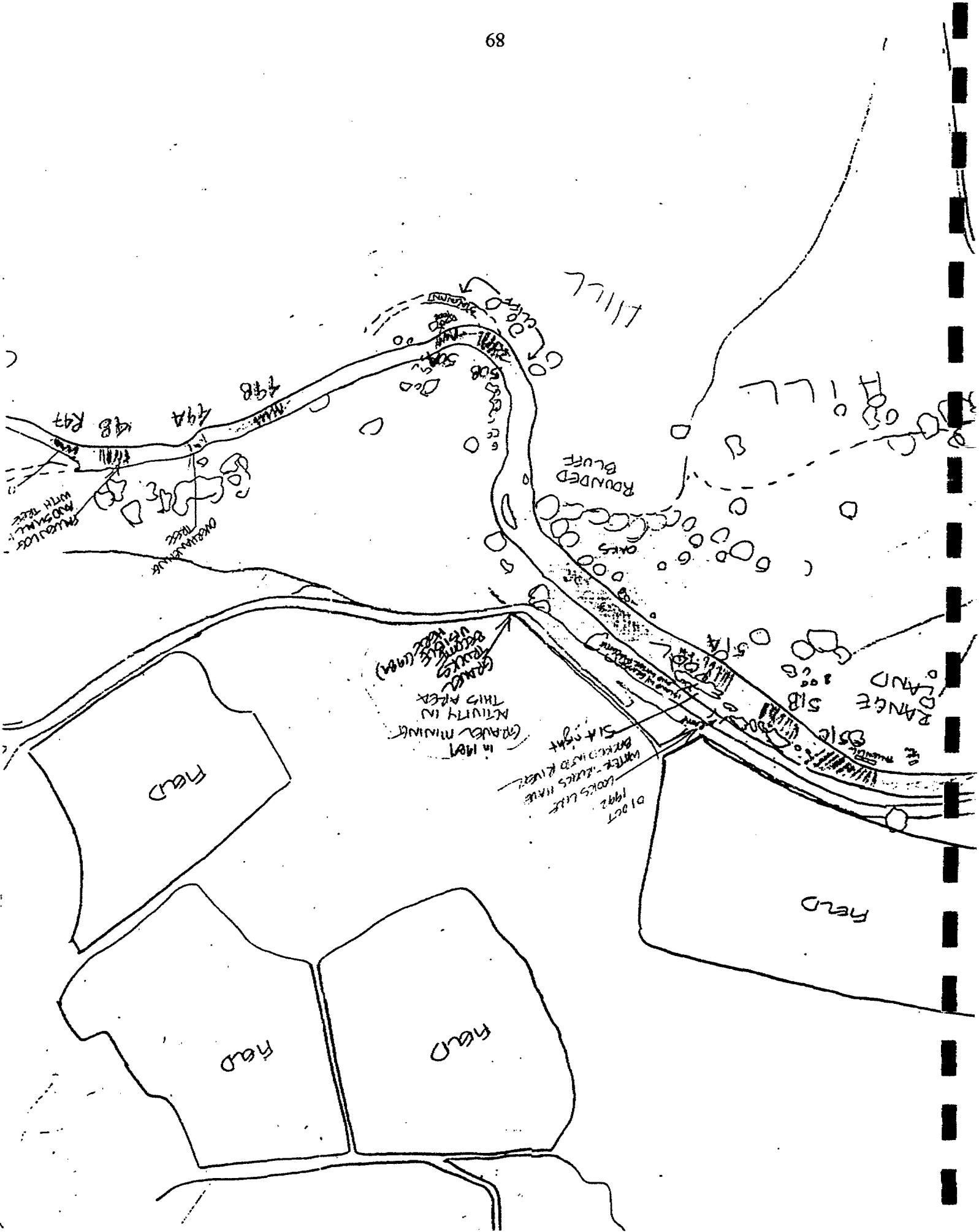
**Merced River**  
**Miles 42.7-45.5**  
**Riffles 41-44, 47-50, 54-58, and 64-66**

This 2.8-mile reach of the Merced River is fairly similar. There is continuous, small-size riparian vegetation along both banks. The channel is approximately 75 feet wide. The reach has good velocities, good drops, easy access, and poor substrate material. Restoration would involve excavating the large, armored cobble and replacing it with graded, washed spawning gravel.

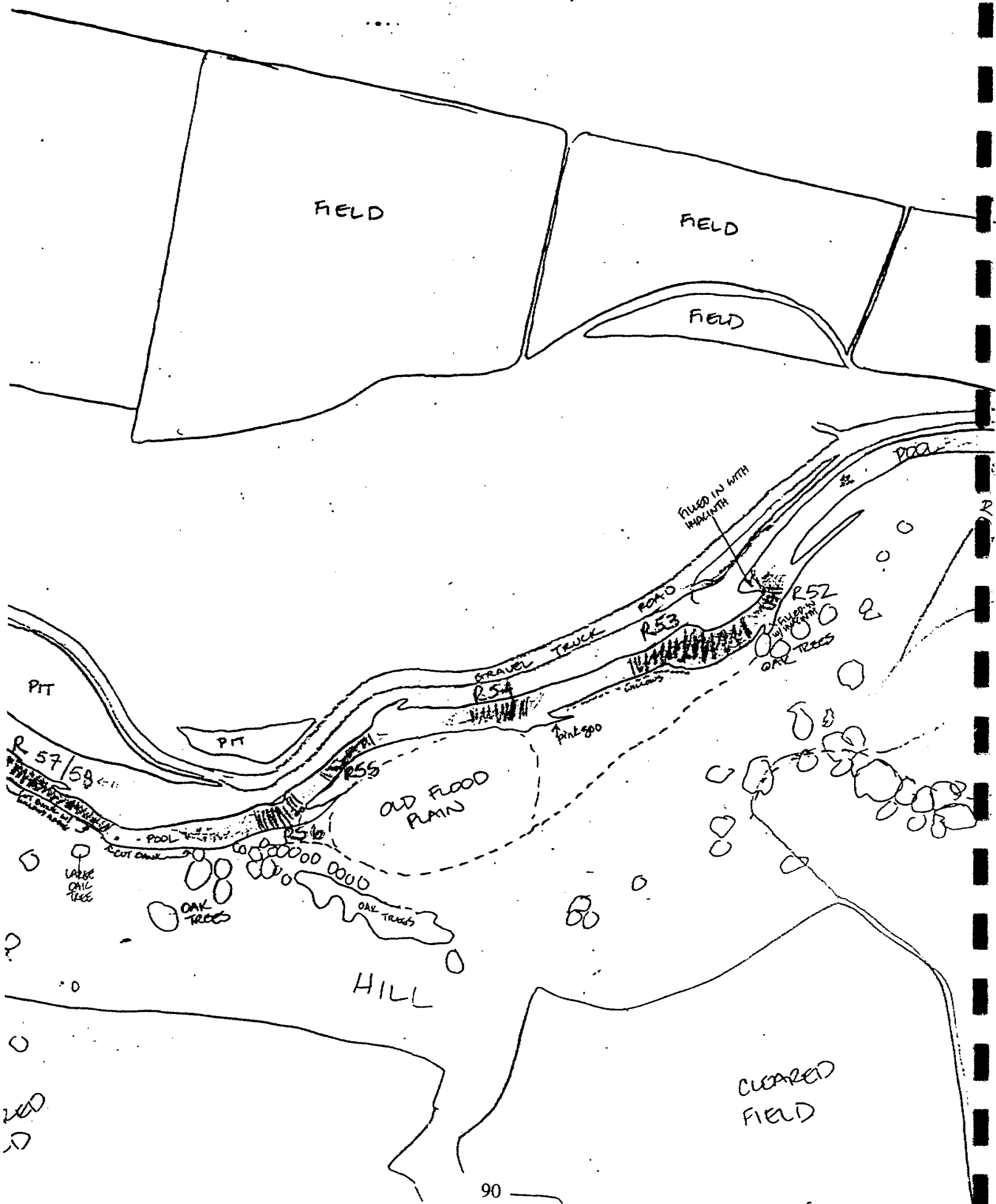
Sixteen individual riffles were identified for potential restoration within this reach. These riffles could be constructed as one large job or in smaller groups. There are four riffle groups ranging from 500 to 800 feet long.

There is cattle grazing along almost all of the south bank in this reach. Cattle grazing tends to damage and inhibit growth of riparian vegetation. In addition, cattle grazing right down to the river causes excessive erosion that can quickly silt in clean gravel. The landowner has expressed a willingness to work with us. He has proposed rotating his cattle so that they are not near the river during spawning season. This will help to some extent, but in the long run any excessive erosion will be detrimental.





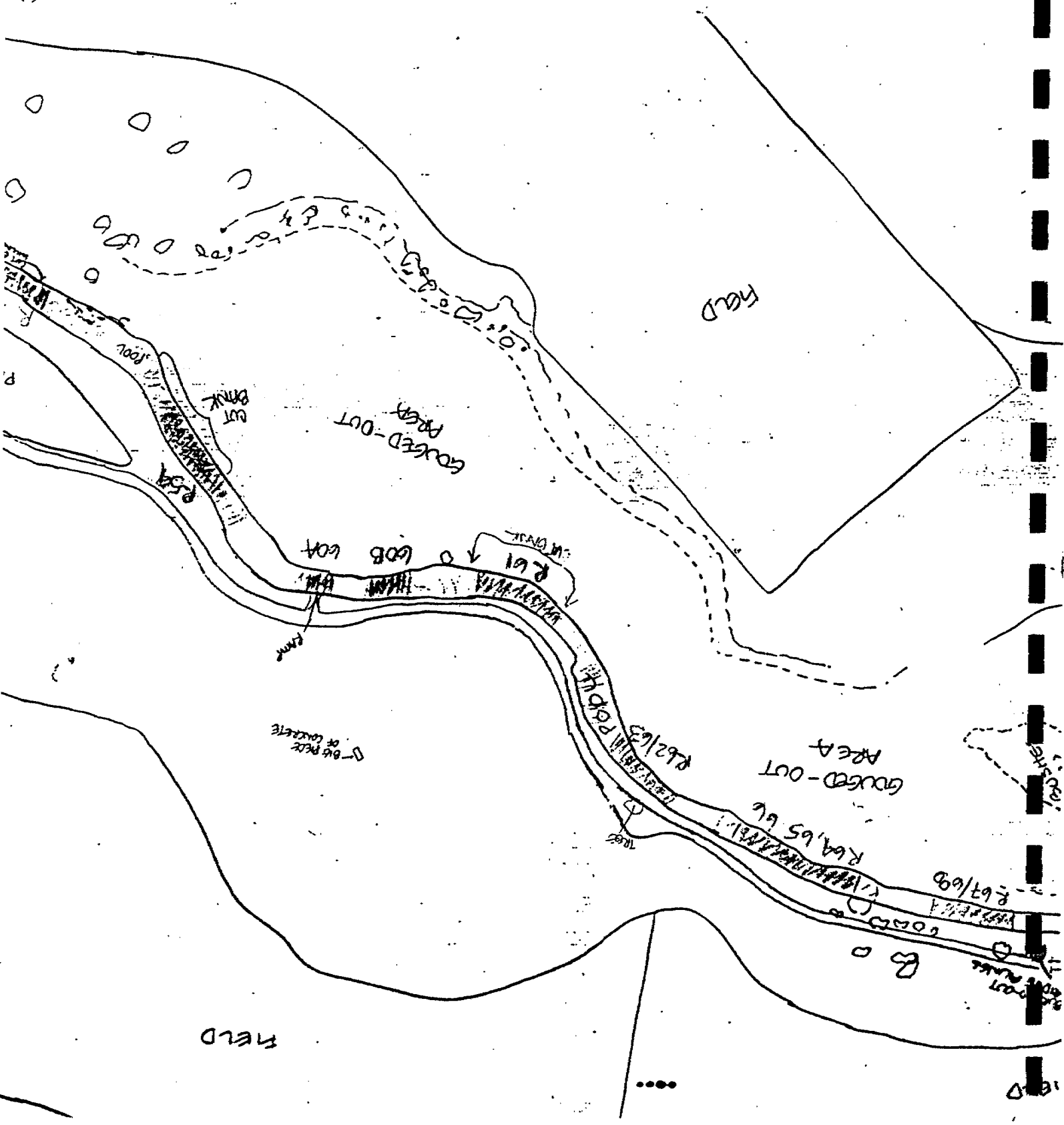




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D-020995

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field



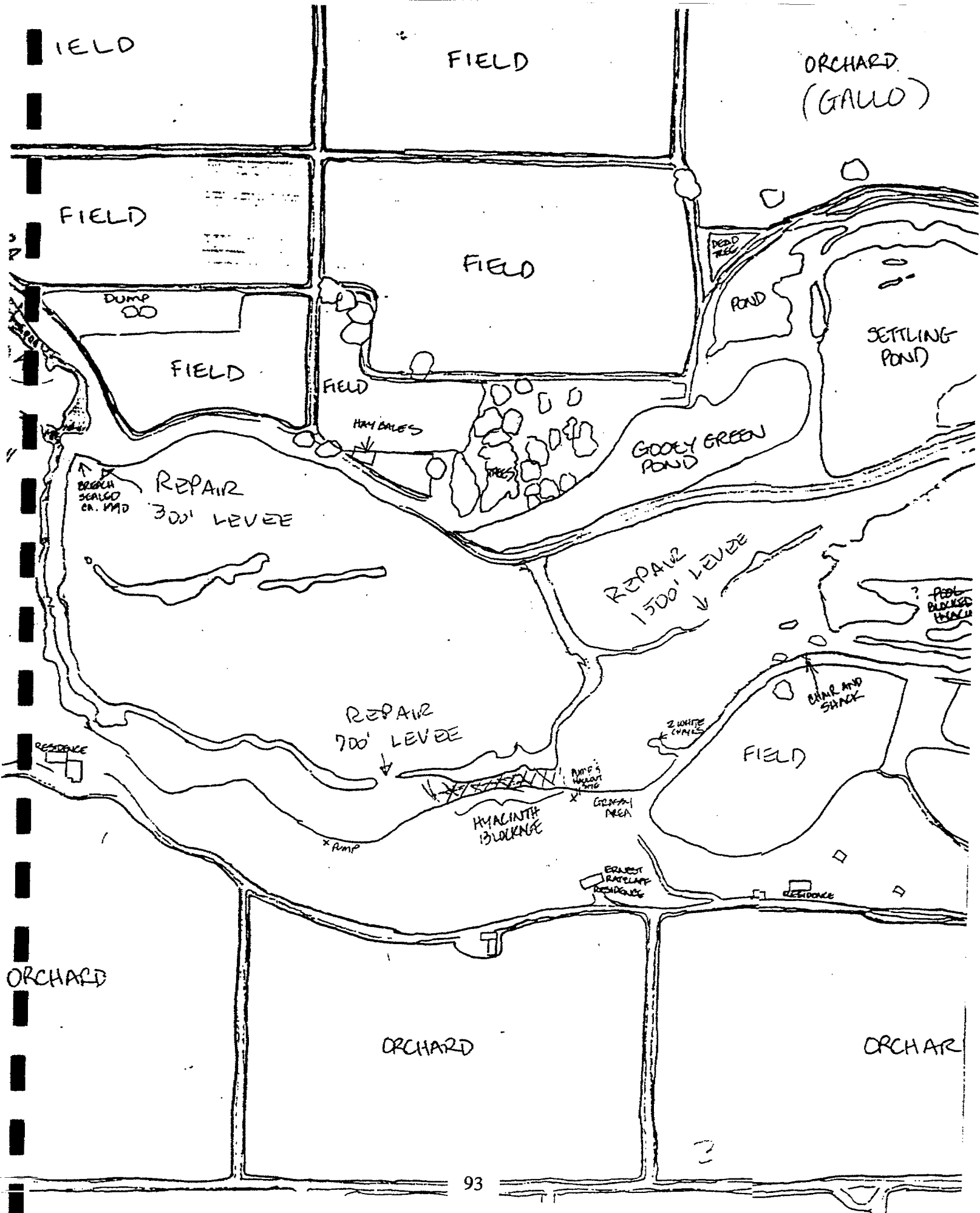
**Merced River  
Mile 40.1-40.5**

Approximately 200 acres of abandoned gravel pits have breached, and the river now passes through them. These pits provide prime habitat for predators of out-migrating salmon smolts.

Restoration would involve isolating the pits from the channel. Repairs to the levees are relatively minor in comparison to the large amount of predator habitat that could be isolated. Three breaches totaling approximately 2,500 feet would need to be sealed.

The actual construction costs would be minor compared to the benefits. However, the cost of preliminary surveying will be significant due to the size of the site, the vegetation, and the depth of water.

The site has good access from both sides, and the landowner on the south side has expressed a willingness to have work go forward.



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